Epoxy Curing Agents and Modifiers

Ancamide® 910 Curing Agent

DESCRIPTION

Ancamide 910 curing agent is a versatile, flexible hardener designed for use with liquid epoxy resin. The engineered chemistry of Ancamide 910 curing agent provides a unique combination of properties not found in other epoxy hardeners. The product delivers outstanding flexibility/peel strength, and it also imparts excellent thermal shock resistance and good electrical properties to epoxy based formulations. Additional features include lower viscosity than conventional polyamides and DOT noncorrosive status. Ancamide 910 curing agent can be used either as a sole curing agent or as a modifier, and it is an ideal choice for electronic potting and encapsulation compounds, two-component adhesive formulations, coatings, civil engineering and composites applications.

ADVANTAGES

- Outstanding flexibility and peel strength
- Excellent thermal shock resistance
- Good electrical properties
- Lower viscosity than standard polyamides
- Excellent adhesion to a wide variety of substrates
- DOT noncorrosive

APPLICATIONS

- Electronic potting and encapsulation compounds
- General-purpose, two-component adhesives where improved adhesion/peel strength is required
- Coatings, civil engineering and composites applications where improved flexibility/crack resistance/adhesion is required

STORAGE AND HANDLING

Refer to the Safety Data Sheet for Ancamide 910 curing agent.

SHELF LIFE

At least 24 months from the date of manufacture in the original sealed container at ambient temperature. Store away from excessive heat and humidity in tightly closed containers.

TABLE 1: TYPICAL PROPERTIES

Appearance	Amber Liquid
Color[1] (Gardner)	6
Viscosity[2] @ 25°C (cP)	6,000
Amine Value[3], mg KOH/g	118
Specific Gravity[4] @ 25°C	.99
Flash Point[5] (°C)	>93
Equivalent Wt/{H}	230
Recommended Use Level (phr,EEW=190)	110-125

TABLE 2: TYPICAL HANDLING PROPERTIES*

Mixed Viscosity[6] @ 25°C (cP)	6,640
Gel Time (150g mix @ 25°F) (min)	120
Thin Film Set Time @ 25°F (h)	8
Peak Exotherm[9] (100 g mass) (°C)	65

TABLE 3: TYPICAL PERFORMANCE*

(7 days cure @ 25°C)	
Glass Transition Temperature[10] (°C)	25
Tensile Strength[11] (psi)	1,000
Tensile Modulus[11] (thousand psi)	114
Tensile Elongation at break[11] (%)	100
Hardness[12] (Shore D)	57

* Ancamide 910 curing agent formulated with standard Bisphenol-A based (DGEBA, EEW=190) epoxy resin.

Footnotes:

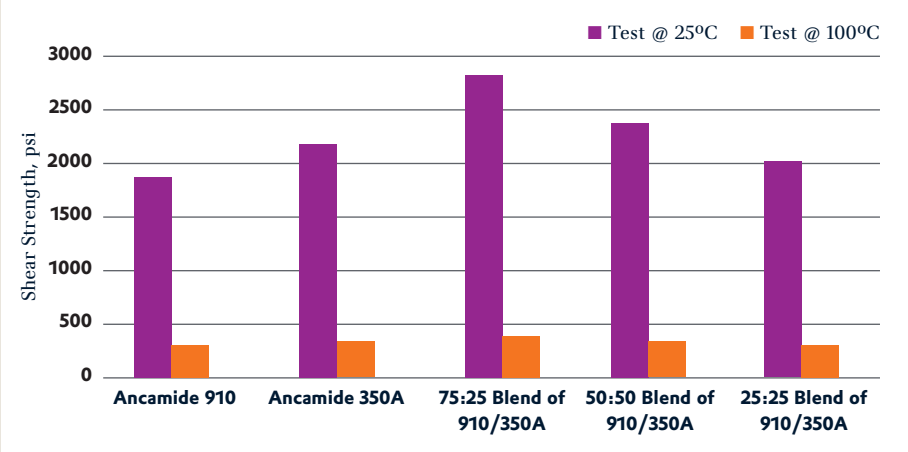
(1) ASTM D1544-80
(2) ASTM D 455-83, Brookfield RV, Spindle 27
(3) Perchloric acid titration
(4) ASTM D 147-85
(5) Seta flash closed cup
(6) ASTM D 455-83, Brookfield RV, Spindle 52
(7) Techne GT-4 gelation timer
(8) BK drying recorder
(9) ASTM D 2471-71
(10) ASTM D 3418-82
(11) ASTM D 638-86
(12) ASTM D 2240-86

SUPPLEMENTAL DATA

ADHESION TO COLD ROLLED STEEL

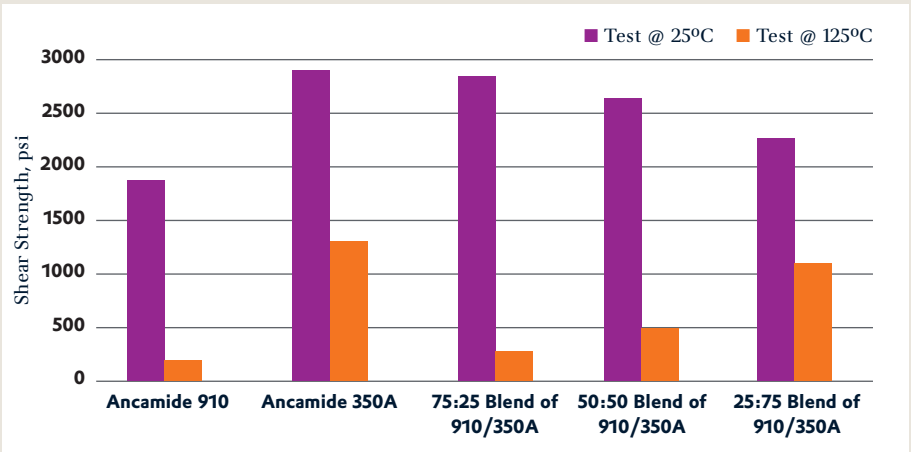
ROOM TEMPERATURE CURE: Ancamide 910 curing agent imparts good flexibility to ambient cured two component epoxy resin formulations when used as a sole curing agent (as shown in Figure 1). Additionally, Ancamide 910 curing agent also reveals a unique synergy with conventional polyamides such as Ancamide 350A curing agent, in that adding as little as 25% of Ancamide 350A curing agent to Ancamide 910 curing agent dramatically enhances the shear strength value beyond what either curing agent would achieve alone (also shown in Figure 1). The results from the strength retention test done at elevated temperature mirror the same synergistic trend, although to a lesser degree.

FIGURE 1: ADHESION TO COLD ROLLED STEEL
SHEAR STRENGTH AFTER 7-DAY CURE AT 25°C



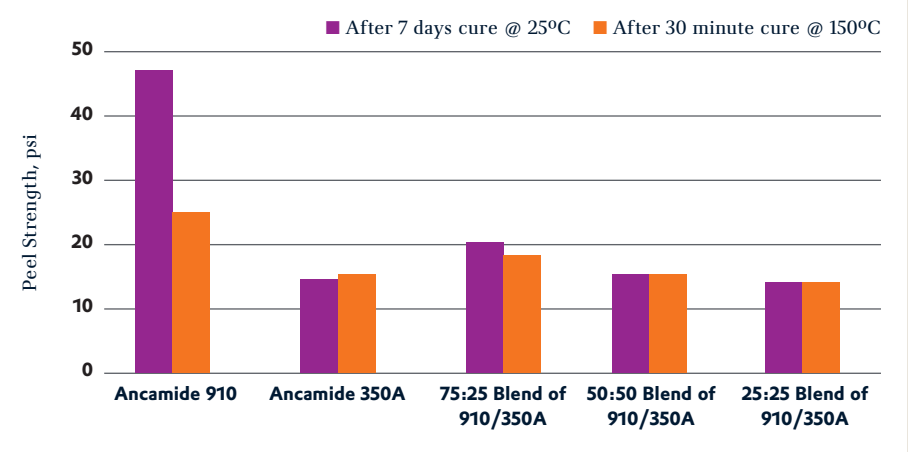
ELEVATED TEMPERATURE CURE: As depicted in Figure 2, Ancamide 350A curing agent outperforms Ancamide 910 curing agent in terms of strength developed after heat cure, as well as in elevated temperature strength retention after heat cure. This comes as no surprise given the distinctive chemistry differences between the two products and the resulting cross-link density variations. Yet once again, a positive synergy is observed when the two curing agents are blended — providing comparable strength after elevated temperature cure while still taking advantage of the properties Ancamide 910 curing agent provides, such as low viscosity and improved flexibility.

FIGURE 2: ADHESION TO COLD ROLLED STEEL
SHEAR STRENGTH AFTER 30-MINUTE CURE AT 150°C



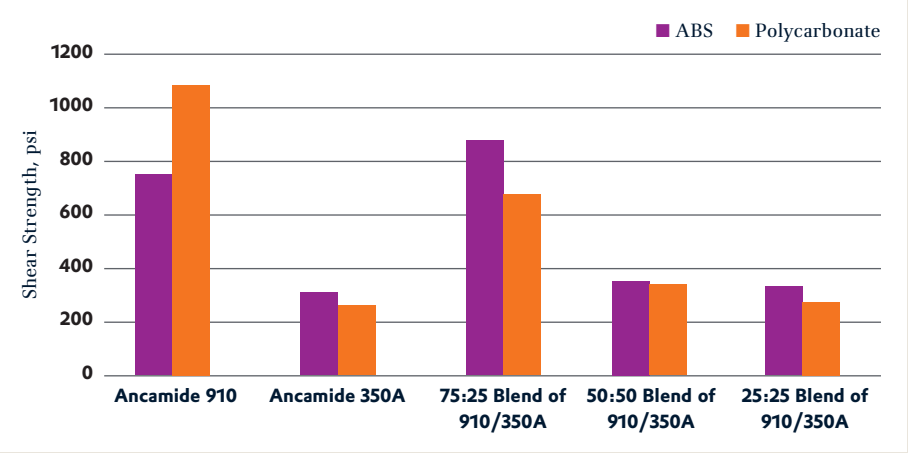
PEEL STRENGTH: One of the best measures of flexibility and adhesion is peel strength. Figure 3 demonstrates the striking improvement Ancamide 910 curing agent offers in peel strength performance relative to Ancamide 350A curing agent and Ancamide 910/Ancamide 350A curing agent blends: more than double the peel strength at ambient temperature, and at least 70% greater strength after heat cure versus Ancamide 350A curing agent.

FIGURE 3: ADHESION TO COLD ROLLED STEEL PEEL STRENGTH AT 25°C



ADHESION TO PLASTICS: The adhesion of Ancamide 910 curing agent and Ancamide 910/350A curing agent blends to plastic is illustrated in Figure 4. On both ABS and polycarbonate substrates, Ancamide 910 curing agent emerges as the clear winner in terms of shear strength, due to its outstanding flexibility. The results when using a 75/25 blend of Ancamide 910 and Ancamide 350A curing agents on ABS substrates are also worth noting. Better performance can be obtained with a combination of the two than either product provides individually.

FIGURE 4: ADHESION TO ABS AND POLYCARBONATE SHEAR STRENGTH AFTER 7-DAY CURE AT 25°C



ADHESION TO ALUMINUM: A 70/30 blend of Ancamide 910 and Ancamide 2482 curing agents in an unoptimized starting formulation was evaluated for adhesion to aluminum. Starting formulation details are given in Appendix B. Results are shown in Figures 5 and 6. The blend shows good adhesion to aluminum, and in both shear strength and peel strength cases, results are slightly improved with heat cure.

FIGURE 5: ADHESION TO ALUMINUM SHEAR STRENGTH

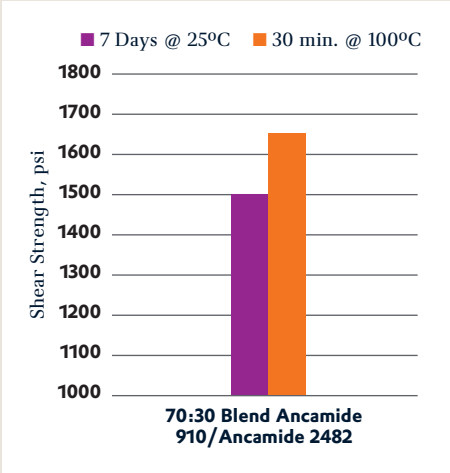
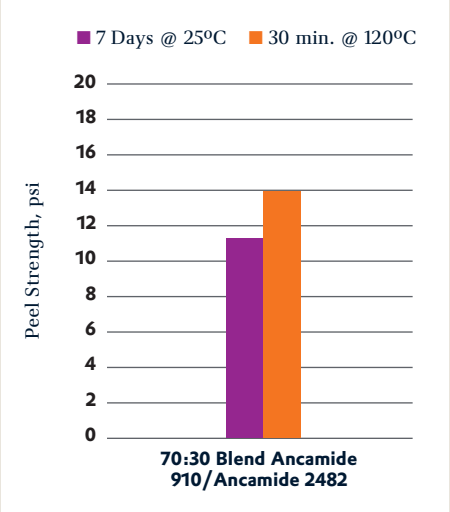
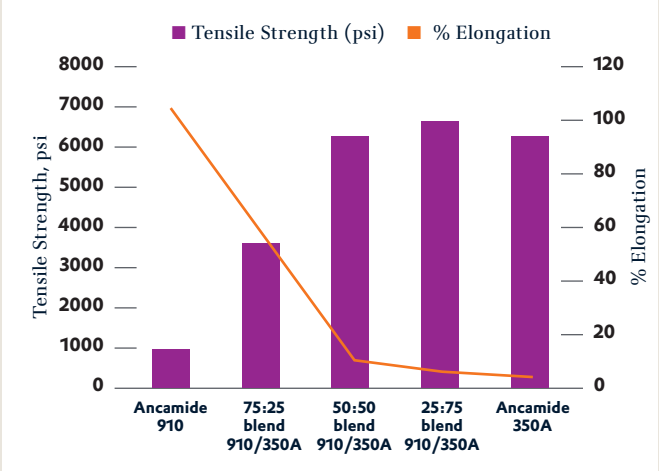


FIGURE 6: ADHESION TO ALUMINUM PEEL STRENGTH



TENSILE STRENGTH: When it comes to tensile strength development, Ancamide 350A curing agent exceeds the performance of that of Ancamide 910 curing agent--again, due to Ancamide 350A curing agent's tighter cross-link density and lower degree of flexibility. The benefit of using both curing agents reappears — this time with the 25/75 blend of Ancamide 910 and Ancamide 350A curing agents, which provides the highest tensile strength of any of the formulations tested. And, as would be predicted, the tighter cross-link density of Ancamide 350A curing agent results in lower elongation, while the more flexible Ancamide 910 curing agent provides 100% elongation. A 75/25 blend (Ancamide 910/Ancamide 350A) of the two provides more moderate elongation performance (60%). Figure 7 provides supporting data..

FIGURE 7: TENSILE PROPERTIES AFTER 2-HOUR CURE AT 70°C

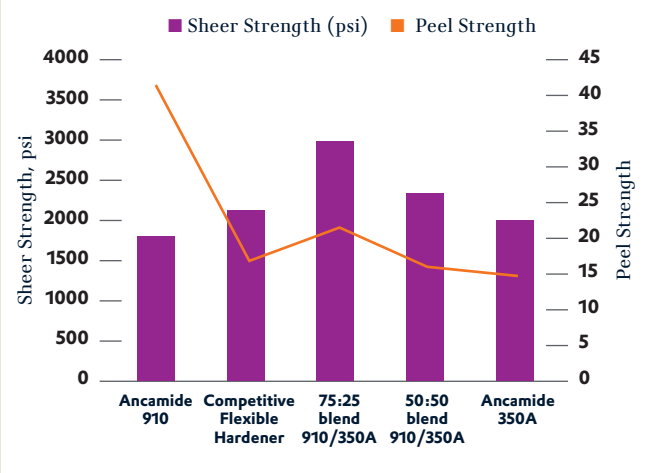


PERFORMANCE VERSUS A COMPETITIVE FLEXIBLE CURING AGENT: To illustrate the uncommon versatility of Ancamide 910 as a problem-solving curing agent for a wide variety of applications, a comparative analysis was conducted between Ancamide 910 curing agent, blends of Ancamide 910 and Ancamide 350A curing agent, and a competitive flexible curing agent. The model formulation used is presented in Appendix A.

In Figure 8, Ancamide 910 curing agent displays the highest peel strength but the lowest shear strength. Ancamide 350A curing agent, on the other hand, displays greater shear strength but lower flexibility/peel strength. The competitive curing agent also offers improved peel strength but with moderate flexibility. The best performance comes from the 75/25 blend of Ancamide 910 and Ancamide 350A curing agents. Given the wide variety of applications and performance requirements a formulator faces on a regular basis, the blend offers a distinct advantage in that the formulator has the ability to tailor the balance of flexibility and

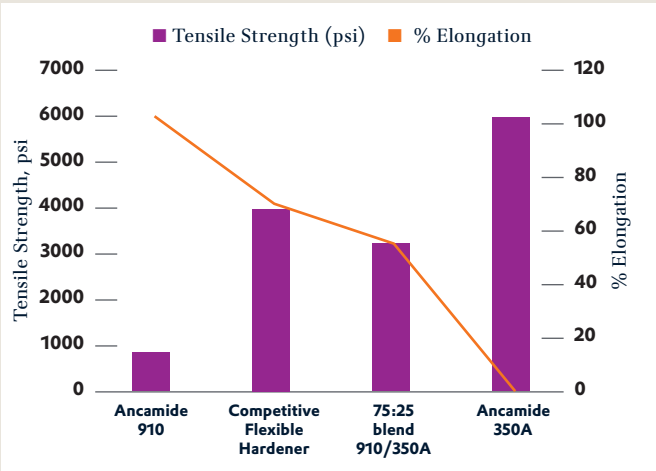
strength precisely to his formulation requirements simply by adjusting the ratios within the Ancamide 910 and Ancamide 350A curing agent blend.

FIGURE 8: ANCAMIDE 910 VS. COMPETITIVE FLEXIBLE HARDENER SHEAR STRENGTH AND PEEL STRENGTH AFTER 7-DAY CURE AT 25°C



In Figure 9, tensile strength data is reported in conjunction with percent elongation results. Once again, Ancamide 910 curing agent displays high flexibility/lower strength; Ancamide 350A curing agent displays high strength/lower flexibility; and the competitive curing agent and the Ancamide 910/Ancamide 350A curing agent blend display moderate strength/percent elongation combinations; with the blend allowing for precise tailoring of the formulation performance to meet the needs of the specific application.

FIGURE 9: ANCAMIDE 910 VS. COMPETITIVE FLEXIBLE HARDENER TENSILE STRENGTH AFTER 2 HOUR CURE AT 70°C



OTHER PERFORMANCE PROPERTIES

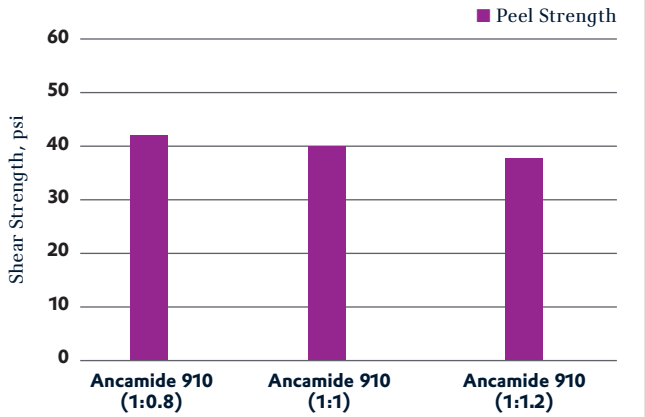
ELECTRICAL INSULATING PERFORMANCE: Ancamide 910 curing agent offers good insulating performance at moderate frequencies, as demonstrated in Figure 10. Its performance begins to deteriorate at higher frequencies, and therefore it is not recommended for use in high voltage applications.

FIGURE 10: ELECTRICAL INSULATING PROPERTIES

Property	ASTM	Value
Dielectric Constant @ 100 kHz	D-150	4.12
Dissipation Factor @ 100 kHz (%)	D-150	0.07
Volume Resistivity (ohm-cm)	D-257	4.22×10^{11}
Dielectric Strength @0.08" (volts/mil)	D-149	550

STOICHOMETRIC LATITUDE RELATIVE TO PEEL STRENGTH: For Ancamide 910 curing agent, going slightly over or slightly under stoichiometry with standard liquid epoxy resin has virtually no effect on the formulation's final flexibility in terms of peel strength, as illustrated in Figure 11.

FIGURE 11: EFFECT OF STOICHIOMETRIC VARIATION ON PEEL STRENGTH



PEAK EXOTHERM: Peak exotherm data was collected for Ancamide 910 and Ancamide 350A curing agent in a 150 g mass. In each case, the curing agent was blended with a stoichiometric amount of standard liquid epoxy resin. Ancamide 910 curing agent displays a peak exotherm temperature of 65 °C versus a peak exotherm temperature of 43°C for Ancamide 350A curing agent.

THERMAL SHOCK RESISTANCE: Ancamide 910 curing agent was evaluated for thermal shock resistance via a "Modified Olyphant Washer Test." No cracking was observed in the Ancamide 910 curing agent-based formulation from cycles 1-10. At cycle 11, the Ancamide 910 curing agent formulation began to soften but did not crack. At cycle 12, the first cracking was observed. Test conditions are noted in Figure 12.

FIGURE 12: TEST CONDITIONS FOR MODIFIED OLYPHANT WASHER TEST

Cycle	Test Condition	Test Time
1	Cool from 25°C to 5°C	10 minutes
2	Heat from 5°C to 25°C	30 minutes
3	Cool from 25°C to -15°C	10 minutes
4	Heat from -15°C to 25°C	30 minutes
5	Cool from 25°C to -35°C	10 minutes
6	Heat from -35°C to 25°C	30 minutes
7	Cool from 25°C to -55°C	10 minutes
8	Heat from -55°C to 25°C	30 minutes
9	Heat from 25°C to 130°C	30 minutes
10	Cool from 130°C to -55°C	10 minutes
11	Heat from -55°C to 150°C	30 minutes
12	Cool from 150°C to -75°C	10 minutes

APPENDICES

APPENDIX A: MODEL ADHESIVE FORMULATION

A Side	Parts by Wt.
DGEBA Liquid Epoxy Resin (EEW=190)	60
Talc (Microtuff 325F)[1]	38
Fumed Silica (Cab-O-Sil TS-720)[2]	2
B Side	
Curing Agent	50
Aluminum (Toyal, 101)[3]	22
Talc (Microtuff 325F)[1]	27
Fumed Silica (Cab-O-Sil TS-720)[2]	1

Curing agents used: Ancamide 350A, Ancamide 910 and blends of the two, as well as a competitive curing agent (AHEW=256) for comparative purposes.

The amount of curing agent was 50 parts in all cases. Mix ratios used were based on a 1:1 stoichiometric ratio. As the curing agents and ratios within blends changed, mix ratios changed as well.

This formulation was used for all tests featured in this brochure unless otherwise designated.

APPENDIX B: FLEXIBLE ADHESIVE FORMULATION

A Side	Parts by Wt.
DGEBA Liquid Epoxy Resin (EEW=190)	50.5
Epodil® 748 reactive diluent	7.0
Talc (Microtuff 325F)[1]	40.0
Fumed Silica (Cab-O-Sil TS-720)[2]	2.5
B Side	
Ancamide 910 Curing Agent	38.0
Ancamide 2482 Curing Agent	15.0
Aluminum (Toyal, 101)[3]	20.0
Talc (Microtuff 325F)[1]	25.0
Fumed Silica (Cab-O-Sil TS-720)[2]	2.0

Mix Ratio: 1:1 by weight and by volume

Footnotes:

(1) Microtuff 325F is manufactured by Barretts Minerals, Inc.
(2) Cab-O-Sil TS-720 is manufactured by Cabot Corporation
(3) Aluminum 101 is manufactured by Toyal-America

APPENDIX C: SUBSTRATES, BONDING PARAMETERS AND TEST METHODS

Substrates	
Cold Rolled Steel	Zinc Phosphate treated cold-rolled steel, 0.032"
Aluminum	Alloy 2024-T3, conforming to specification B 209, 63-mil thickness for lap shears, 20-mil thickness for T-peels
ABS	Dow Pulse 830, 180 °F bake material, 1/8"
Polycarbonate	General Electric Lexan LS, 250 °F bake material, 1/8"
Surface Preparation	
Cold Rolled Steel	Dry rag wipe
Aluminum	Phosphoric Acid Anodizing
ABS and Polycarbonate	Dry rag wipe
LAP SHEAR SAMPLE PREPARATION AND TESTING	
1" x 4" coupons	
0.5" overlap for metals and 1.0" overlap for thermoplastic substrates	
0.010" bond line thickness (including glass micro-beads; 1g/100 g of mixed adhesive formulation)	
Testing according to ASTM D1002	
T-PEEL SAMPLE PREPARATION AND TESTING	
1" x 4" coupons	
3" bond overlap	
0.010" bond line thickness (including glass micro-beads; 1g/100 g of mixed adhesive formulation)	
Testing according to ASTM D1876	
CURE SCHEDULES	
As indicated.	
TEST CONDITIONS	
As indicated.	

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